

Microstructure of impurity phase inclusions in gray cast iron and their composition

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Abstract. It is quite difficult to control the content of carbide-forming elements in the production of casting 'pressure plate' of gray pearlitic iron grade SCh25 (GOST 1412–85). Therefore, it is necessary to conduct research and analysis of foreign inclusions, the basis of which are 'uncontrolled' carbide formers. The analysis of the content of 'uncontrolled' carbide-forming elements on the formation of zones with an interdendritic distribution of graphite types D, E (ASTM A247) castings of a pressure plate is carried out. The elemental composition of impurity inclusions is determined. It has been established that 'uncontrolled' carbide-forming elements are represented in cast iron in complex carbide-nitride and sulfide-phosphide phases. A conclusion is drawn on the effect of carbide formers on the formation of areas with an interdendritic distribution of graphite. All types of these phases are concentrated to a greater extent within the zones of interdendritic distributions of lamellar graphite D and E. This indirectly confirms the influence of 'uncontrolled' carbide-forming elements on their formation.

1. Introduction

The manufacturer is faced with problems of inconsistency of the structure and material properties of castings with the established regulatory requirements during the development of new foundry products. One of the reasons for such deviations is already observed at the beginning of the processor chain and is associated with the unsatisfactory quality of the charge materials used for melting [1–3]. This is manifested in the presence of 'uncontrolled' carbide-forming elements entering the molten iron from waste high-strength steels and noticeably worsening the morphology of the graphite phase in the manufacture of cast iron castings [4–8].

This problem manifested itself, in particular, when the 'Pressure plate' casting of pearlite gray cast iron grade SCh25 (Russian state standard GOST 1412–85 [9]) was put into production. It is relevant to conduct research and analysis of the presence, size, distribution and elemental composition of foreign inclusions (mainly uncontrolled carbide formers) to correct the 'infected' steel component of charge materials. Also relevant is the study of their influence on the formation of adverse interdendritic distributions of graphite.

2. Methods and Materials

Electron microscopic images and X-ray spectra were obtained using a Carl Zeiss Sigma scanning electron microscope (Germany) (resolution of the electron column at an optimal WD of 1.3 nm; range



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of movement: X – 125 mm; Y – 125 mm; Z – 50 mm; tilt 0 –90°; 360° rotation). The microscope is equipped with an EDAX analytical system (USA) with an Apollo detector and a Hikari back-scattered electron detector.

The object of the research was the casting ‘Pressure plate’ made of gray cast iron of pearlitic class grade SCh25.

Part of the electron microscopic photographs and the results of X-ray spectral microanalysis are shown in Figures 1–4. Figures 1, 2 show the sections of the middle part of the casting, Figures 3, 4 show the edge sections of the casting.

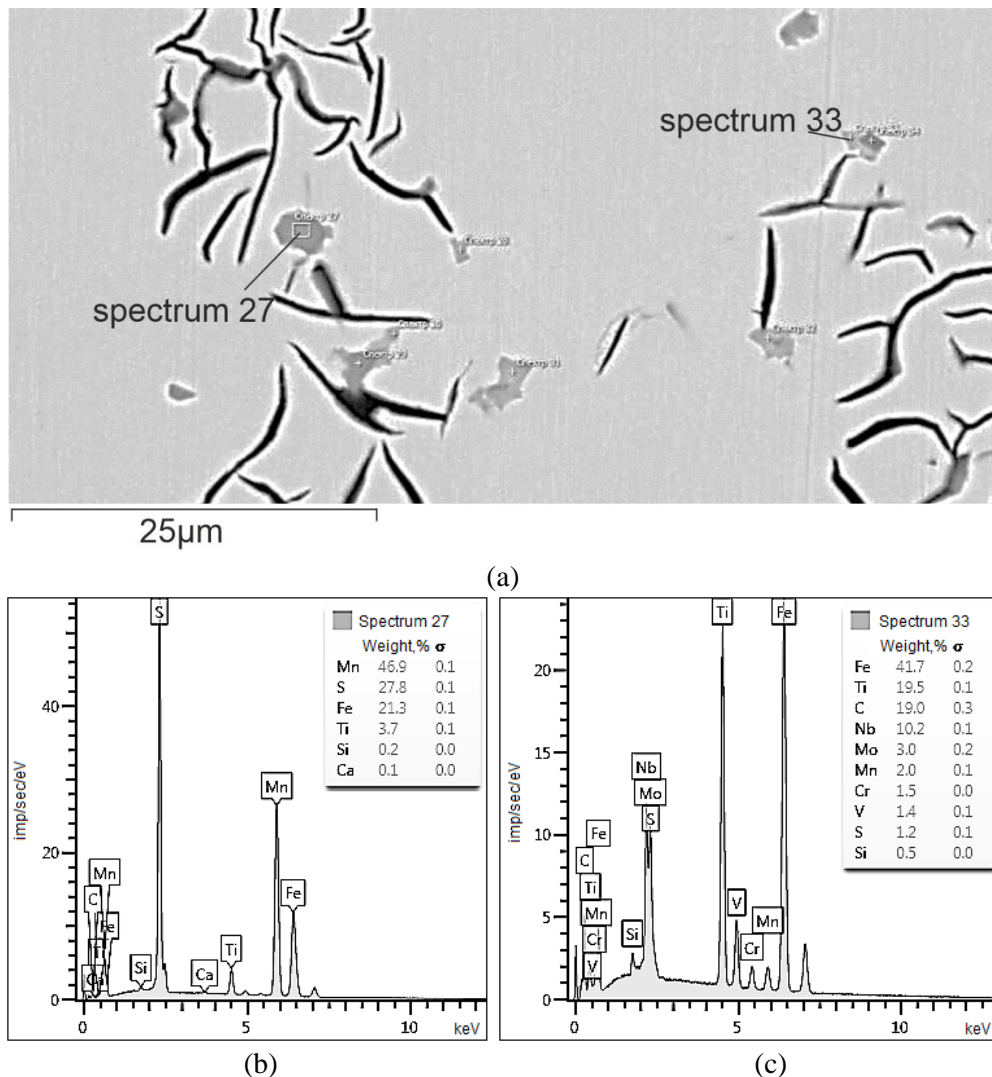


Figure 1. Electron microscopic image of the middle part of the casting(a) and X-ray spectra of sulfide (b) and carbide (c) inclusions (marked by the rectangle and the cross).

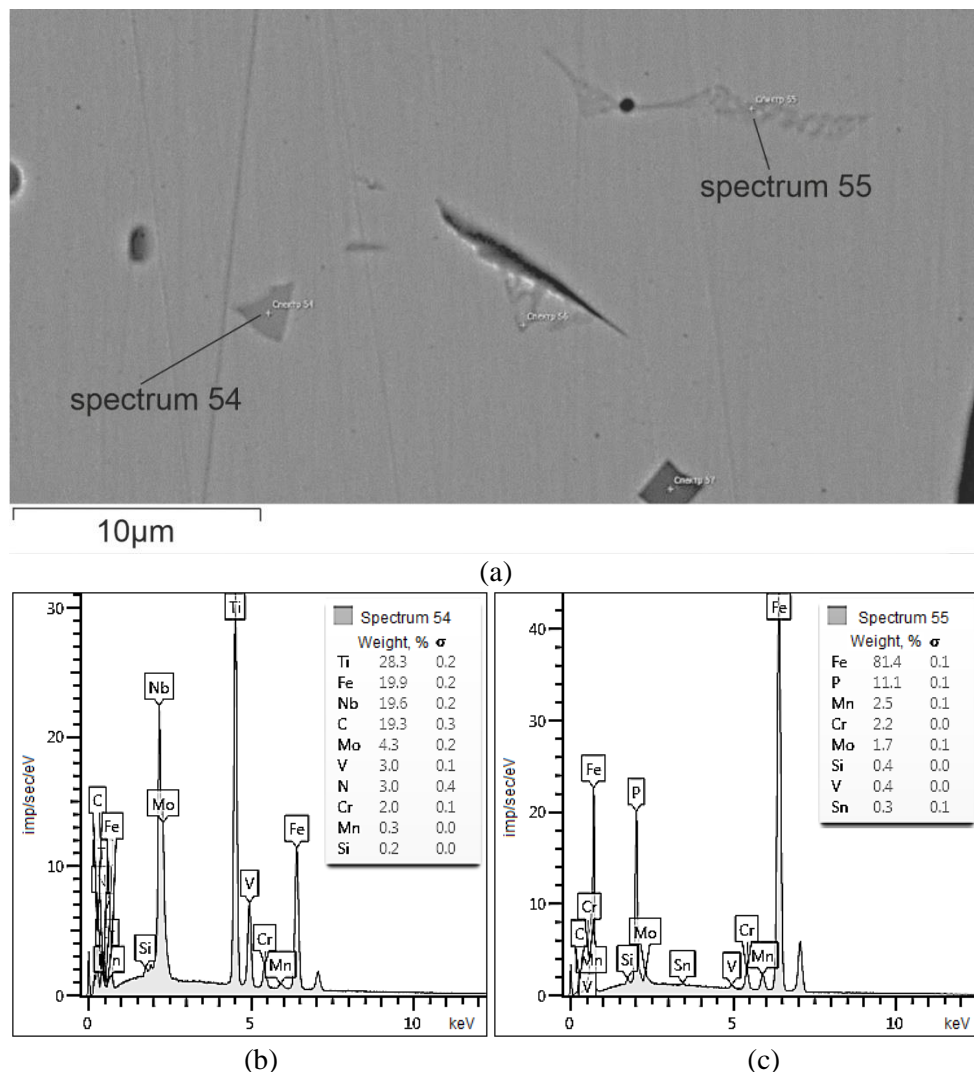


Figure 2. Electron microscopic image of the middle part of the casting (a) and X-ray spectra of carbonitride inclusion (b) and phosphide eutectic (c)(marked by crosses)

The degree of gray in these images characterizes the chemical composition of the test substance (the lighter - the greater the sequence number of the constituent elements according to the periodic table). The numerical results of the weight content of elements in the above X-ray spectral analysis are of a qualitative nature.

3. Result and Discussion

According to the results of electron microscopy analysis using x-ray spectral microanalysis, it was found that 'uncontrolled' carbide-forming elements such as zirconium, vanadium, titanium, tungsten, niobium and molybdenum coming from charge materials are represented in cast iron in complex carbide-nitride and sulfide-phosphide phases.

In complex phases of a compact form based on complex ferromanganese sulfides, such chemical elements as (together and separately) vanadium, titanium, molybdenum, niobium, tungsten and zirconium are concentrated. Separate phases of this type are sulfide-phosphide, because additionally contain phosphorus. In isolated cases, phosphide eutectic inclusions with dissolved uncontrolled carbide-forming impurity elements are found, morphologically different from the rest of the inclusions and presented as fragments of a broken network.

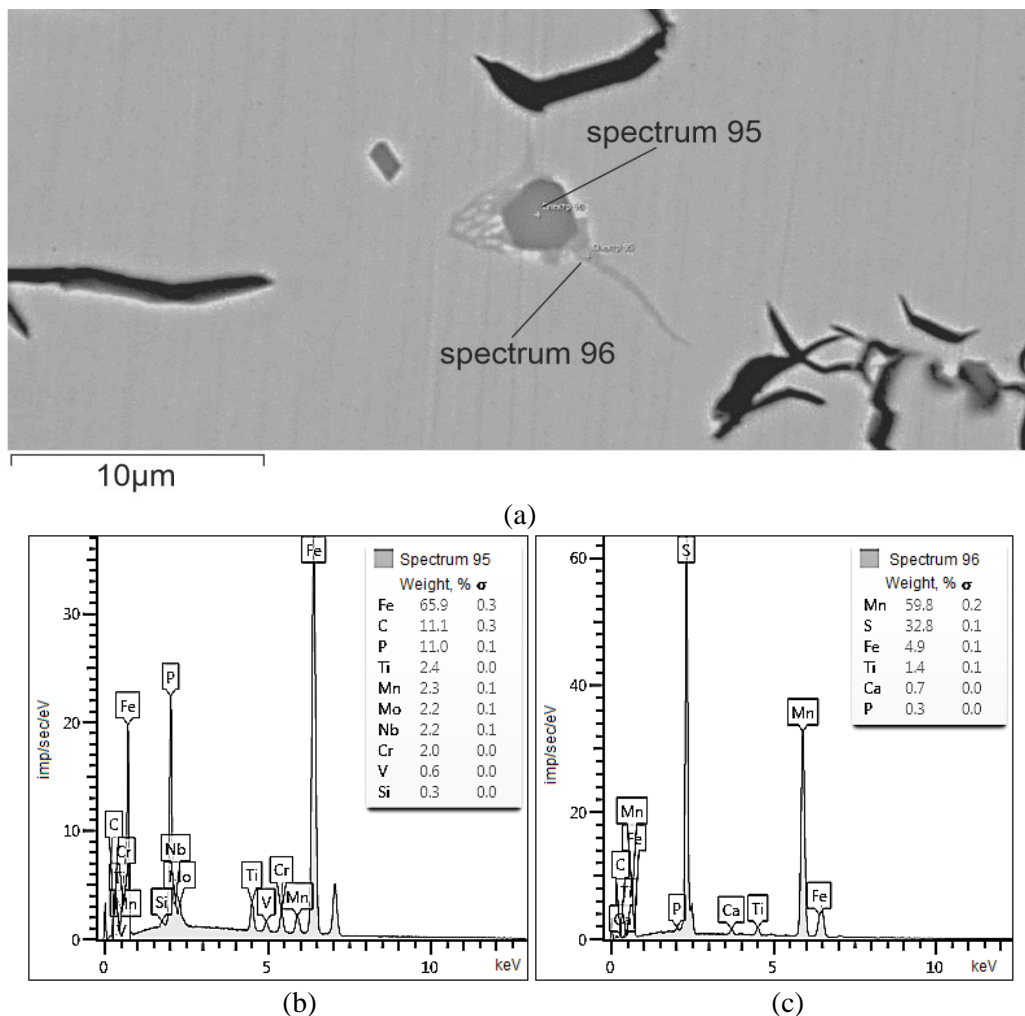


Figure 3. Electron microscopic image of the edge of the casting (a) and X-ray spectra of the phosphide eutectic (b) and sulfide inclusion (c) (marked by crosses)

In complex carbide phases, mostly elongated and irregular shape, such chemical elements are concentrated in various combinations as vanadium, titanium, molybdenum, niobium, tungsten and zirconium. The individual phases of this type are carbonitrides, because additionally contain nitrogen.

In some cases, both types of these inclusions are combined into a conglomerate in the form of dark sulfide of a compact form with a light elongated carbide periphery.

4. Conclusion

All types of carbide-nitride and sulfide-phosphide phases are concentrated to a greater extent within the zones of interdendritic distributions of lamellar graphite PGr8 and PGr9 (GOST 3443–87 [10]) (D and E according to ASTM A247 [11]) both in the extreme parts of the sample and in its core. This indirectly confirms the influence on their formation of 'uncontrolled' carbide-forming elements that increase the tendency of molten iron to chill hard spots.

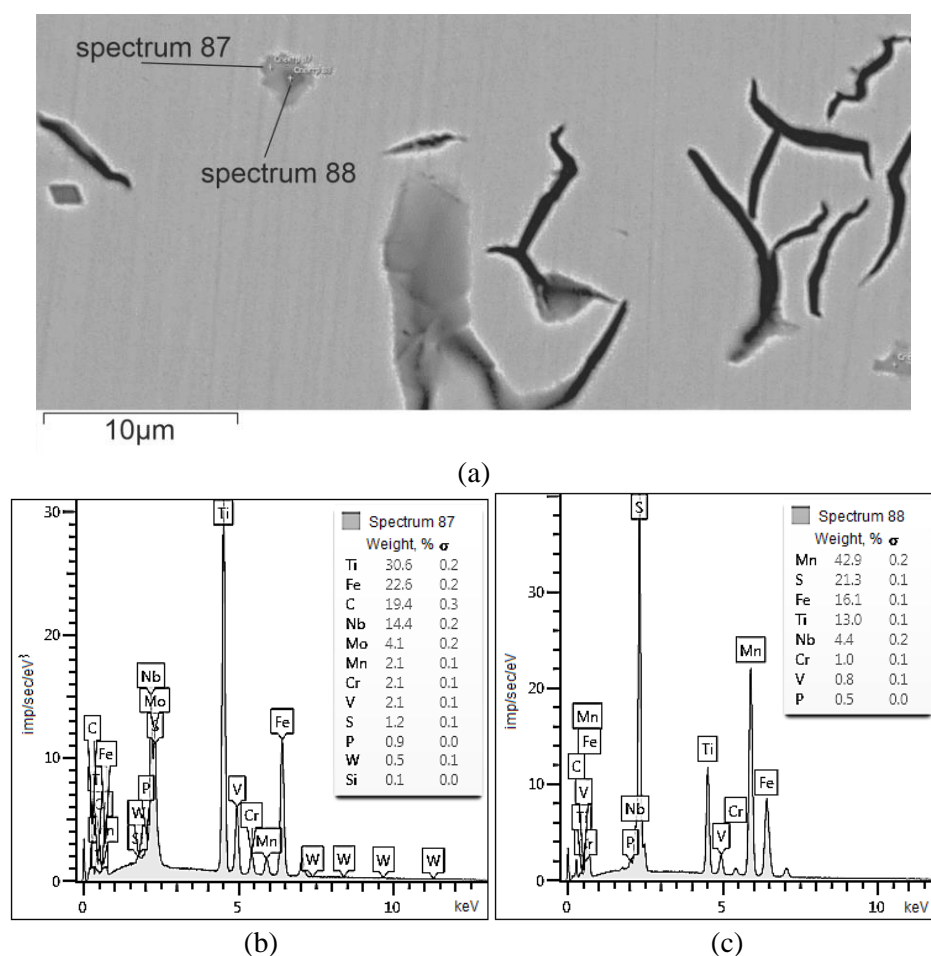


Figure 4. Electron microscopic image of the edge of the casting *a* and X-ray spectra of the carbide *b* and sulfide inclusions *c* (marked by crosses)

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